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# REDUCING ENERGY CONSUMPTION AT AIRPORTS IN SOUTH AFRICA: INVESTIGATING TECHNOLOGIES THAT REDUCE ELECTRICITY CONSUMPTION

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***ABSTRACT***

***Reducing energy consumption through energy efficiency and energy conservation is key as a first step to reducing carbon emissions. It is also essential on the journey to adopting alternative low carbon energy sources such as renewable energy. This paper presents an investigation into technologies that will reduce energy consumption at airports in South Africa, through estimating their energy reduction impact and the required investment and return on investment.***

***KEYWORDS: Electricity Reduction Technologies, Energy Reduction for Airports, LED Lighting, Lighting Control, Geyser Sleeve Technology, Low Emissivity Glass, Double Glazing, Energy Savings with Air Conditioning***

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**Original Article**

## INTRODUCTION

In the journey towards reducing electricity consumption, it is necessary to ascertain the energy consumption and corresponding carbon footprint and identify the drivers of energy consumption related to a particular site [1].This exercise will highlight energy wastage. Airports' most significant energy users are lighting and air conditioning [1]. It is thus important that all efforts to reduce carbon emissions through energy efficiency and energy conservation focus on lighting and air conditioning and the systems that contribute or affect the demand for them. Technologies for lighting and air conditioning at the airports must be kept up to date. Factors that contribute to increased energy consumption must be addressed to ensure reduced energy consumption.

Building and interior refurbishments are opportunities to alter designs to complement the lighting and space thermal requirements to promote efficiency and reduce demand. Replacement cycles of infrastructure such as chillers, motors, fans, cooling towers, chilled water pipe runs, lighting, buildings management systems, buildings insulation, building facades and envelope, interior designs, etc. should be regarded as an opportunity to incorporate the best available technology and designs that promote reduction in energy consumption, monitoring, measuring and control of energy consumption for continued improvement in performance.

This paper presents the interventions identified for reduction in electricity consumption for nine airports in South Africa owned and operated by Airports Company South Africa (ACSA), namely, O R Tambo International Airport (ORTIA) (Kempton Park, Gauteng), Cape Town International Airport (CTIA) (Western Cape), King Shaka International Airport (KSIA) (Durban, KwaZulu-Natal), Port Elizabeth International Airport (PEIA) (Eastern Cape), East London Airport (EL) (Eastern Cape), Bram Fischer International Airport (BFIA) (Bloemfontein, Free State), George Airport (GG) (Eastern Cape), Upington International Airport (UPIA) (Northern Cape) and Kimberley Airport (KIM) (Northern Cape).

The focus of this study is on the reduction in carbon emissions in lighting and air conditioning systems at ACS airports and those factors that affect it. Lighting projects focus on changing lighting systems to LED (light emitting diode) technology, and on controlling the lighting according to lighting demand. The adoption of geyser sleeve technology is to control the supply of hot water according to demand. Air conditioning projects focus on reducing the demand by investigating the adoption of low emissivity glass or double glazing for terminal building glass facades, and of solar thermal-deflecting coating on terminal building roof surfaces [2].Air conditioning projects also investigate the implementation of air conditioning system additions that will control the supply of air conditioning accurately and efficiently to suit the need. Solar thermal energy to power air conditioning chillers is also investigated.

For each of the feasibility studies, an economic model was used, drafted by ACSA's economic modelling department. The economic model yields the net present value (NPV), internal rate of return (IRR), the nominal payback period and the profitability index (PI). The IRR is compared to ACSA's 11.5 % weighted average cost of capital (WACC) rate (2018) to determine economic feasibility. When the NPV is zero or positive is it an investment that pays itself off during its economic lifespan. The NPV equation used in the economic model is given below (Equation 1). The IRR is the return ($i$ in the below equation) when the NPV is zero. When the IRR is greater than the discount rate (or the WACC rate), then the investment is feasible for the business [2].

$$NPV = \sum_{t=0}^{T} \frac{R_t}{(1+i)^t} \qquad \text{Equation (1)}$$

Where:

$R_t$ = net cash inflows – outflows during a single period $t$

$i$ = discount rate or return that could be earned

$t$ = number of time periods

Due to the number of economic models run for all the projects presented here, a summarized economic result is presented giving the NPV and IRR for each investment.

The work presented here was undertaken in FY2018/19, i.e., from 1 April 2018 to 31 March 2019 using the energy consumption of FY2017/18, i.e., from 1 April 2017 to 31 March 2018 as a baseline for comparison. Table 1 gives the energy consumption of the airports for the period 1 April 2017 to 31 March 2018 and was used to determine the impact of the projects in percentage reduction of electricity consumption from the national electricity grid (which is also the % reduction in carbon footprint).

**Table 1: Airports' Energy Consumption for the Period 1 April 2017 to 31 March 2018**

| | Airport | Electricity Consumption in kWh (FY2017/18) | Corresponding Carbon Footprint in kgs using 1 kWh = 1.03 kgs $CO_2$ | Electricity Tariff (ZAR/kWh) 2018 Basis |
|---|---|---|---|---|
| 1 | O R Tambo International Airport | 116 095 091.39 | 119 577 944.13 | ZAR 1.47 /kWh |
| 2 | Cape Town International Airport | 68 717 158.26 | 70 778 673.01 | ZAR 1.47 /kWh |
| 3 | King Shaka International Airport | 33 863 920.76 | 34 879 838.38 | ZAR 1.29 /kWh |
| 4 | Port Elizabeth International Airport | 7 445 125.50 | 7 668 479.27 | ZAR 1.29 /kWh |
| 5 | East London Airport | 4 228 300.00 | 4 355 149.00 | ZAR 0.60 /kWh |

| | | | | |
|---|---|---|---|---|
| 6 | Bram Fischer International Airport | 3 243 412.98 | 3 340 715.37 | ZAR 1.36 /kWh |
| 7 | George Airport | 1 977 241.50 | 2 036 558.75 | ZAR 0.68 /kWh |
| 8 | Upington International Airport | 782 479.00 | 805 953.37 | ZAR 1.10 /kWh |
| 9 | Kimberley Airport | 647 276.00 | 666 694.28 | ZAR 1.56 /kWh |

The electricity reduction projects given in the following sections provide a guide for airports to investigate the onsite specific conditions and make adjustments as necessary to individual projects per airport. Most adjustments will come from their light fitting count and corresponding energy savings. The results given here confirm the feasibility of the intervention, providing guidance to the airports on their focus areas to reduce electricity consumption.

**1. Lighting**

Lighting contributes at least 50 % of an airports' electricity consumption [1].LED light is a mature technology and the best available technology when it comes to reduced energy consumption. The fundamental component of LED technology (Figure. 1) is the use of a semiconductor material that is engineered to glow when energy that induces a current passes through it.

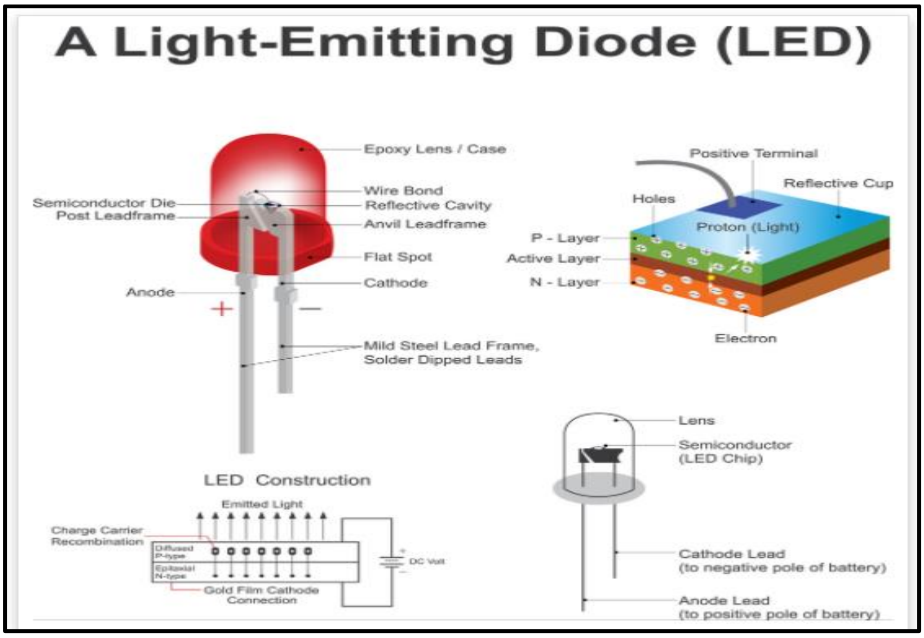


**Figure 1: Components of an LED Light [3].**

Due to most of the airports' lighting not being LED technology, there is a significant opportunity to reduce energy consumption of lighting. Some of the smaller airports in the group have implemented LED lighting and the opportunity to reduce energy consumption is relatively smaller there. Due to the airports having thousands of light fittings and the lack of accurate as-built drawings, the estimate of the number of light fittings to be replaced and the estimated energy savings and other criteria were assumed. Assumptions for each airport are provided in Table 2.

**Table 2: Assumptions For Each Airport**

| | Airport | Assumptions | Number of Light Fittings to be Changed |
|---|---|---|---|
| 1 | ORTIA | Assuming: lighting burns 24 hours a day, 7 days a week; 50% of total electricity consumption is due to lighting; that 40% of the lighting has been changed to LED (20% of total electricity load is efficient). Therefore: 60% of the lighting needs to be changed to LED, i.e., 30% of total electricity load can be reduced by half, i.e., a saving of 15% on total electricity consumption, assuming an average of 50W per fitting. | 79 517 |
| 2 | CTIA | | 47 067 |
| 3 | KSIA | Assuming: lighting burns 24 hours a day, 7 days a week; 50% of total electricity consumption is due to lighting; 20% of the lighting has been changed to LED (10% of total electricity load is efficient).Therefore: 80% of the lighting needs to be changed to LED, i.e., 40% of total electricity load can be reduced by half, i.e., a saving of 20% on total electricity consumption, assuming an average of 50W per fitting | 30 926 |
| 4 | PEIA | Assuming: lighting burns 24 hours a day, 7 days a week; 50% of total electricity consumption is due to lighting; that 40% of the lighting has been changed to LED (20% of total electricity load is efficient).Therefore: 60% of the lighting needs to be changed to LED, i.e., 30% of total electricity load can be reduced by half, i.e. a saving of 15% on total electricity consumption, assuming an average of 50W per fitting. | 5 099 |
| 5 | EL | | 2 896 |
| 6 | BFIA | | 2 222 |
| 7 | GG | | 1 354 |
| 8 | UPIA | | 536 |
| 9 | KIM | | 443 |

Based on the assumptions provided in Table 2 and using an average cost of ZAR 1200 per average 50W supplied and installed, the feasibility indicators and savings are given per airport in Table 3. The lifespan of the light fittings are five years with zero maintenance cost. The annual maintenance cost savings were not included in the economic modelling. The execution of the lighting retrofit for the purposes of the feasibility study is taken to be complete by September 2021.

**Table 3: Feasibility of LED retrofitting nine airports in South Africa**

| | Airport | Cost (ZAR Million) | NPV (ZAR Million) | IRR (%) | Annual kWh Reduction | Annual Cost Savings of kWhs Saved (ZAR Million) 2018 basis | Result |
|---|---|---|---|---|---|---|---|
| 1 | ORTIA | 95.42 | 12.740 | 16.80 | 17 414 263.71 | 25.60 | Feasible |
| 2 | CTIA | 56.48 | 7.51 | 16.70 | 10 307 573.70 | 15.15 | Feasible |
| 3 | KSIA | 37.11 | 0.94 | 12.50 | 6 772 784.00 | 8.74 | Feasible |
| 4 | PEIA | 6.12 | 0.14 | 12.40 | 1 116 768.75 | 1.44 | Feasible |
| 5 | EL | 3.48 | -1.42 | -7.00 | 634 245.00 | 0.41 | Unfeasible |
| 6 | BFIA | 2.67 | 0.18 | 14.20 | 486 511.80 | 0.66 | Feasible |
| 7 | GG | 1.63 | -0.61 | -5.20 | 296 586.15 | 0.20 | Unfeasible |
| 8 | UPIA | 0.64 | -0.06 | 7.80 | 117 371.85 | 0.13 | Unfeasible |
| 9 | KIM | 0.53 | 0.10 | 18.80 | 97 091.40 | 0.15 | Feasible |

LED retrofits are feasible for ORTIA, CTIA, KSIA, PEIA, BFIA and KIM, however, these are not feasible for EL, GG and UPIA. Further reduction in electricity consumption for lighting can be achieved by controlling the supply of lighting according to the need for lighting.

**2. Lighting Control**

Lighting control to meet lighting demand involves the installation of smart electronics in occupancy sensors, building management system programmes to control lighting supply according to operations, and varying light intensity (dimming functions) to provide the lux levels needed for the space.

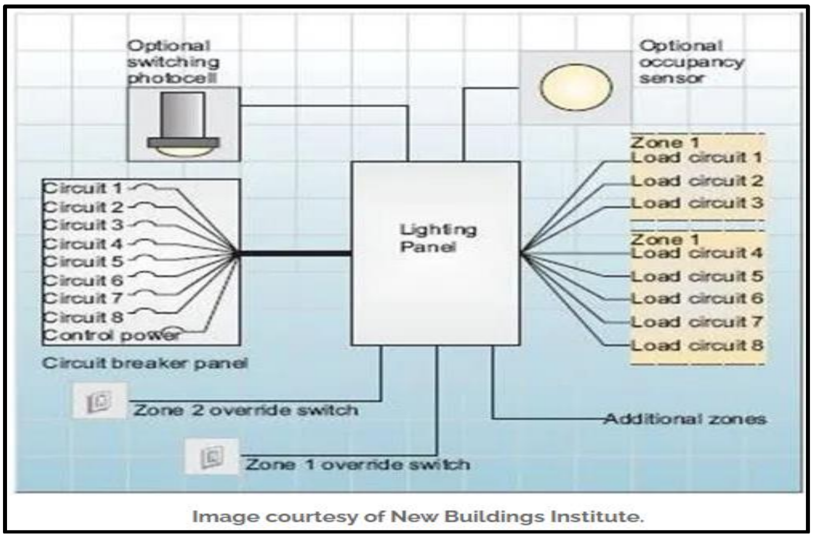


**Figure 2: Typical Lighting Control [4].**

Figure 2 shows typical lighting control. Figure. 3 shows that lighting control technologies can also be extended to other building services such as air conditioning. Wireless means of building services control can also reduce cost and inconvenience as opposed to physical wiring.

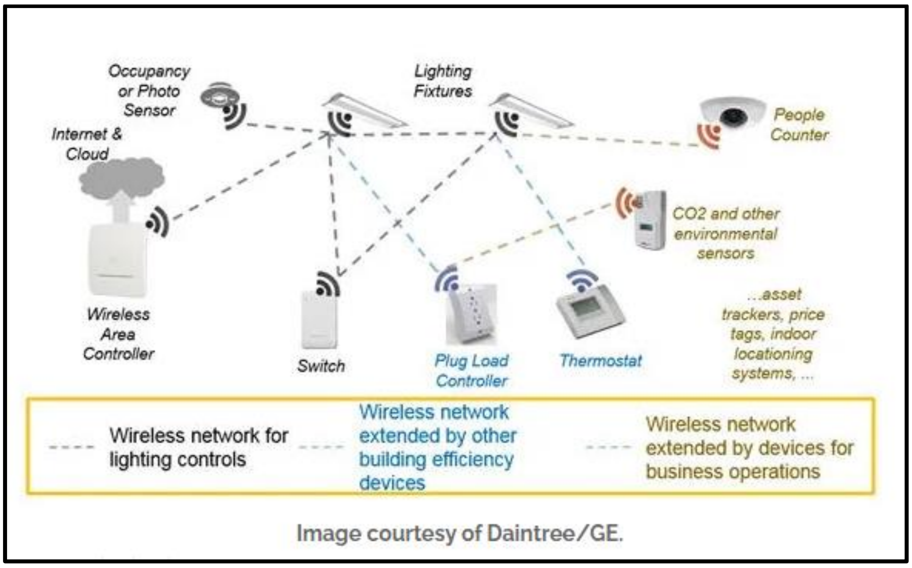


**Figure 3: Lighting Control [4].**

To get an indication of the feasibility of installing lighting control, an approximation of total electricity savings from lighting control is assumed to be 10 % of the total electricity consumption of the site. It is also assumed that the average cost per 10 light fittings for lighting control is ZAR 1 800 with a lifespan of 15 years and zero maintenance cost. The execution of the lighting control for the airports for the purposes of the feasibility study are to be completed by September 2021. The feasibility results are given in Table 4.

**Table 4: Feasibility of Lighting Control for nine Airports in South Africa**

| | Airport | Estimated Number of Light Fittings | Cost (ZAR Million) | NPV (ZAR Million) | IRR (%) | Annual kWh Reduction | Annual Cost Savings of kWhs Saved (ZAR Million) 2018 Basis | Result |
|---|---|---|---|---|---|---|---|---|
| 1 | ORTIA | 132 529 | 23.86 | 131.57 | 68.80 | 11 609 509.14 | 17.07 | Feasible |
| 2 | CTIA | 78 444 | 14.12 | 77.88 | 68.80 | 6 871 715.80 | 10.10 | Feasible |
| 3 | KSIA | 38 657 | 6.96 | 32.98 | 61.60 | 3 386 392.08 | 4.37 | Feasible |
| 4 | PEIA | 8 499 | 1.53 | 7.25 | 61.60 | 744 512.50 | 0.96 | Feasible |
| 5 | EL | 4 827 | 0.87 | 1.68 | 34.80 | 422 830.00 | 0.27 | Feasible |
| 6 | BFIA | 3 703 | 0.67 | 3.36 | 64.40 | 324 341.20 | 0.44 | Feasible |
| 7 | GG | 2 257 | 0.41 | 0.86 | 36.40 | 197 724.10 | 0.13 | Feasible |
| 8 | UPIA | 893 | 0.16 | 0.63 | 53.90 | 78 247.90 | 0.01 | Feasible |
| 9 | KIM | 739 | 0.13 | 0.52 | 53.90 | 64 727.60 | 0.10 | Feasible |

Lighting control technologies for all airports are feasible and a very attractive investment as the IRR for all airports exceeds 30 %.

**3. Geyser Sleeve**

Another electricity user where electricity consumption is often used inefficiently resulting in wastage, is water heating at airports. Some airports in ACSA use large geysers that heat in excess of 150 litres of water for a simple hand-wash at ablution facilities (needing less than a litre per hand wash) and staff shower facilities which are not used often, but they can heat in excess of 200 litres all day, every day. The geyser sleeve technology which is a technology that allows a smaller amount of water to be heated and only when that amount is used up, more water is heated. It resembles a bladder or silicone sleeve called the Hot Spot (Figure. 4)that is able to hold 50 litres or less that can be retrofitted into a geyser effectively heating up a smaller amount of water each time which is more effective and suits the peak and off-peak demands for hot water.

**Figure 4: SindiswaQayi and her Invention, the HotSpot Geyser Sleeve [5].**

The geyser sleeve technology is a South African invention by a woman in the Eastern Cape (SandiswaQayi – Figure. 4) and was tested and endorsed by the CSIR (Council for Scientific and Industrial Research),and is partnered with the Department of Science and Innovation (DSI). The CSIR is South Africa's central and premier scientific research and development organisation. It was established by an act of parliament in 1945 and is situated on its own campus in the city of Pretoria in the province of Gauteng, South Africa.

It is assumed that the energy consumption of an average 200 litre geyser is 10 kWhs per day and that the geysers run for 365 days a year.The energy saving per retrofit is advertised to be proven to be 27% per geyser with a lifespan of 10 years and zero maintenance cost.The execution of the retrofitting of the airports' geysers with the HotSpotfor the purposes of the feasibility study is to be completed by September 2019. Table 5 gives the feasibility results.

**Table 5: Feasibility of Retrofitting the Geyser sleeve (HotSpot) at Airports in South Africa**

| | Airport | Number of Geysers to be Retrofitted | Cost (ZAR Million) | NPV (ZAR Million) | IRR (%) | Annual kWh Reduction | Annual Cost Savings of kWhs Saved (ZAR Million) 2018 basis | Result |
|---|---|---|---|---|---|---|---|---|
| 1 | ORTIA | 100 | 0.11 | 0.820 | 129.60 | 98 550.00 | 0.14 | Feasible |
| 2 | CTIA | 20 | 0.02 | 0.25 | 184.90 | 19 710.00 | 0.03 | Feasible |
| 3 | KSIA | 20 | 0.02 | 0.14 | 115.10 | 19 710.00 | 0.03 | Feasible |
| 4 | PEIA | 15 | 0.02 | 0.11 | 115.20 | 14 782.50 | 0.02 | Feasible |
| 5 | EL | 15 | 0.02 | 0.04 | 58.50 | 14 782.50 | 0.01 | Feasible |
| 6 | BFIA | 10 | 0.01 | 0.08 | 121.20 | 9 855.00 | 0.01 | Feasible |
| 7 | GG | 10 | 0.01 | 0.03 | 65.40 | 9 855.00 | 0.01 | Feasible |
| 8 | UPIA | 10 | 0.01 | 0.06 | 100.10 | 9 855.00 | 0.01 | Feasible |
| 9 | KIM | 10 | 0.01 | 0.09 | 137.40 | 9 855.00 | 0.02 | Feasible |

The geyser sleeve technology retrofit for all airports are feasible and very attractive investment as the IRR for allairports exceeds 50 %.

### 3. Double Glazing or low Emissivity Glazing

The difference between indoor and outdoor temperature drives heat transfer. Introducing a thermal barrier prevents or reduces the rate of heat ingress into a building in summer and insulates the building in winter. Traditional single glazing without treatments to limit solar thermal energy make for poor temperature barriers.Introducing double glazing sandwiching a space either filled with air (Fig. 5) or an inert gas or even a vacuum drastically reduces heat transfer by at least 50 %.

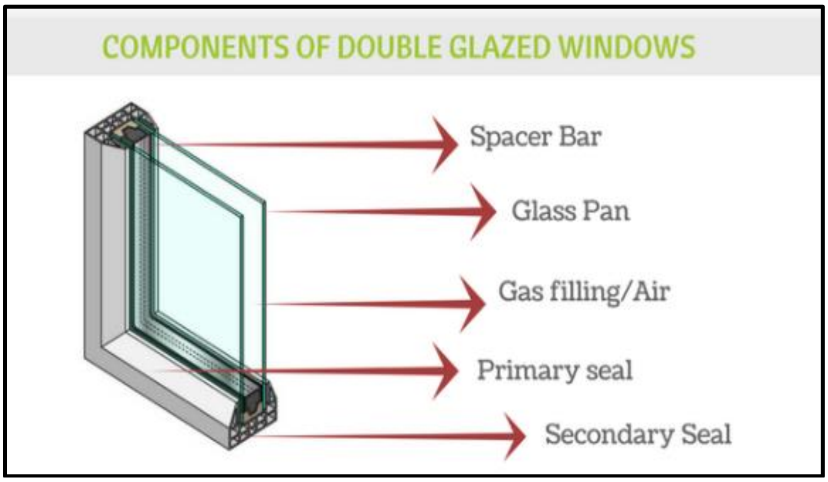


**Figure 5: Components of Double Glazed Windows [6].**

Terminal buildings have at least one exposed side that is a glass facade facing either the rising or the setting sun. The heat transfer coefficient (U-value) of traditional single glazing is 5.7 W/m$^2$K and double glazing (air filled) or low emissivity glass has a U-value of 2.8 W/m$^2$K. This shows an estimated 50% more heat transference with single glazing terminal building facades. The feasibility study shows the financial viability of replacing all sun-exposed glass facades at terminal buildings with glazing of a U-value of 2.8 W/m$^2$K versus a traditional single glazing of U-value 5.7 W/m$^2$K during replacement cycles in January 2029.

The CLTD(cooling load temperature difference) [7] method uses Equation (2) to calculate heat ingress into the space:

$$Q = U \times A \times (T_{outdoor} - T_{indoor}) \quad \text{Equation (2)}$$

Equation (2) is used to calculate the energy savings. A lifespan of 20 years is used for the investment. Table 6 gives the data used for the calculations of the feasibility results contained in Table 7.

**Table 6: Data used for the Feasibility Study of the Retrofitting of Single Glazing with 2.8 W/M2KGLAZING for Sun-Exposed Glass Facades at Airports in South Africa**

| | Airport | Total Area of Glazing Considered for 2.8 W/m$^2$K Glazing | Area Assumptions | CDD (22.5 ℃ base) | HDD (18.0 ℃ base) | Total DD | Energy Savings (kWhs) |
|---|---|---|---|---|---|---|---|
| 1 | ORTIA | 2400 | Exposed glass facade has a length of 800 m on the eastern side (airside), drop of 3 m is assumed | 148 | 1132 | 1280 | 259 413.12 |
| 2 | CTIA | 1950 | Exposed glass facade has a length of 650 m on the eastern side (airside), drop of 3 m is assumed | 143 | 0 | 143 | 56 459.52 |
| 3 | KSIA | 1000 | Exposed glass facade has a length of 500 m on the eastern side (airside), drop of 2 m is assumed | 232 | 0 | 232 | 35 148.00 |
| 4 | PEIA | 240 | Exposed glass facade has a length of 120 m on the eastern side (airside), drop of 2 m is assumed | 95 | 702 | 797 | 17 873.28 |
| 5 | EL | 577 | Used exact figures from actual measurements | 135 | 516 | 651 | 37 107.10 |
| 6 | BFIA | 400 | Exposed glass facade has a length of 200 m on the eastern and western sides which are exposed areas, drop of 2 m is assumed | 405 | 1528 | 1933 | 61 415.04 |
| 7 | GG | 340 | Exposed glass facade has a length of 170 m on the eastern and western side that are exposed, drop of 2 m is assumed | 100 | 1019 | 1119 | 32 940.29 |
| 8 | UPIA | 450 | Exposed glass facade has a length of 150 m on the eastern and western sides that are exposed areas, drop of 3 m is assumed | 1081 | 867 | 1948 | 69 561.72 |
| 9 | KIM | 520 | Exposed glass facade has a length of 260 m on the eastern side (airside), drop of 2 m is assumed | 629 | 1120 | 1749 | 73 180.22 |

**Table 7: Feasibility of Replacing Single Glazing at Airports in South Africa with a 2.8 W/m2K Glazing**

| | Airport | Cost in ZAR Millions at Year of Implementation | Year of Implementation | NPV (ZAR Million) | IRR (%) | Annual Cost Savings of kWhs saved (ZAR Million) 2018 basis | Result |
|---|---|---|---|---|---|---|---|
| 1 | ORTIA | 14.80 | January 2029 | -0.58 | 9.90 | 0.38 | Unfeasible |
| 2 | CTIA | 11.44 | January 2029 | -2.70 | 0.30 | 0.08 | Unfeasible |
| 3 | KSIA | 6.17 | January 2029 | -1.30 | 0.30 | 0.05 | Unfeasible |
| 4 | PEIA | 1.48 | January 2029 | -0.19 | 5.50 | 0.02 | Unfeasible |
| 5 | EL | 3.56 | January 2029 | -0.80 | -0.80 | 0.02 | Unfeasible |
| 6 | BFIA | 2.35 | January 2029 | 0.07 | 12.50 | 0.08 | Feasible |
| 7 | GG | 2.10 | January 2029 | -0.37 | 2.70 | 0.02 | Unfeasible |
| 8 | UPIA | 2.78 | January 2029 | -0.06 | 10.60 | 0.08 | Unfeasible |
| 9 | KIM | 3.21 | January 2029 | 0.15 | 13.30 | 0.11 | Feasible |

It can be seen from Table 7 that replacing single glazing with low emissivity glass is generally not feasible for the airports, except for BFIA and KIM.The extreme nature of temperatures there relative to the airports in the other geographical locations, combined with their electricity tariffs, make their installations feasible. For the other airports, the cost of low emissivity glazing needs to be reduced and or the electricity tariffs must be significantly higher in order to make such a project feasible.

**4. Electricity Savings with Air Conditioning**

Air conditioning contributes between 20 % and 30 % of an airports' total electricity consumption, depending on whether the air conditioning system also provides space heating [1].Centralized air conditioning systems consists of many components and parts whose functions are controlled electronically. One of the challenges of air conditioning control is to ensure that the chiller produces enough chilled water at the correct temperature and that this is distributed at the right time to air handling units that will adequately cool the air circulated from the space, mixing it with just the right amount of fresh air as needed.

Centralized air conditioning systems usually have a fixed setpoint at which chilled water is produced in the chiller, and air handling units usually introduce fresh air through a process that is not necessarily controlled. This fixed setpoint of chilled water production most-times has the capacity to cool much more than is needed and this wastes energy. The chilled water quantity and air flow rates need to be actively controlled to ensure that the correct amount of cooling is achieved. By actively controlling the chilled water setpoint to meet the cooling demand, energy is saved. When the fresh air rate is not controlled or restricted to ensure that the air properties are kept within specific limits, the air handling units must work harder, increasing cooling demand. Controlling fresh air demand according to the needs of the conditioned space saves energy. This presents two energy saving interventions for air conditioning systems:

- Chilled water setpoint control; and
- Fresh air demand control.

Producing chilled water is one of the most energy intensive processes in air conditioning, consuming significant amounts of electricity. To offset this electricity consumption, solar thermal energy can be harvested to power the absorption chillers, which will reduce electricity consumption and the carbon footprint. The feasibility of adopting solar thermal powered absorption chillers for PEIA, EL, BFIA and GG,based on these being smaller airports with centralized HVAC systems, is presented. UPIA and KIM airports have decentralized HVAC systems. The feasibility of adopting active chilled water setpoint control sand fresh air demand controls for the centralized air conditioning systems at ORTIA and CTIA are considered, based on the implementation of such systems at KSIA.

**4.1 Solar Thermal Powered Absorption Cooling**

Using the costs of an absorption chiller system powered by solar thermal energy for the Pretoria Moot Hospital [8] (Fig. 6), the cost per kW of the absorption cooling system is given in Table 8.


**Figure 6: U-Pipe Solar Thermal Collectors (left) and 35kW Absorption Chiller (right) from the Pretoria Moot Hospital Installation [8].**

**Table 8: Cost of a Solar Thermal Absorption Cooling System Calculated per kW**

| Item | Quantity | Cost (2018 Basis) in ZAR |
|---|---|---|
| 35 kW Yazaki absorption chiller | 1 | 314 234.03 |
| Solar collectors (U-pipe evacuated tubes of 1.8 $m^2$) | 40 | 441 109.76 |
| Hot water storage tank (6000 litres capacity) | 1 | 187 200.00 |
| controllers/sensors, hardware, software, electronics (PlantVisor Pro) | 1 | 184000.00 |
| Balance of plant (BOP) (piping, pumps, structural support, expansion tank, etc.) | 1 | 288 000.00 |
| **Total cost of system in ZAR (2018 basis)** | | 1 414 543.79 |
| **Total cost of the system in ZAR per kW** | | **40 415.54** |

The feasibility study uses 15 years as the economic lifespan of the installation, electricity consumption savings from the grid for 12 hours of the day (where chilled water production is powered by the solar thermal energy plant),annual maintenance cost of the solar thermal absorption HVAC plantestimated at5 % of the capital cost of the plant, with a 1 year construction period. The feasibility study results are given in Table 9.

**Table 9: Feasibility of Adoption Solar Thermal Absorption Cooling for Selected Airports**

| | Airport | Size of System (kW) | Year of Implementation | Cost (ZAR million) | NPV (ZAR Million) | IRR (%) | Annual kWh Reduction from the Electricity Grid | Annual Cost Savings of kWh Saved (ZAR Million) 2018 basis | Result |
|---|---|---|---|---|---|---|---|---|---|
| 1 | PEIA | 200 | 2024 | 10.37 | 1.22 | 14.40 | 876 000.00 | 1.13 | Feasible |
| 2 | EL | 200 | 2023 | 10.37 | -3.54 | 0.80 | 876 000.00 | 0.56 | Unfeasible |
| 3 | BFIA | 60 | 2021 | 2.82 | 0.36 | 14.00 | 262 800.00 | 0.36 | Feasible |
| 4 | GG | 60 | 2023 | 3.11 | -0.88 | 2.90 | 262 800.00 | 0.18 | Unfeasible |

Table 9 shows that solar thermal powered absorption cooling is feasible for PEIA and BFIA and unfeasible for EL and GG airports. The electricity tariffs for the installations play a critical role in their financial viability.

### 4.2 Active Chilled Water Set Point Control and Fresh air Demand Control

KSIA has already implemented the active chilled water setpoint control and fresh air demand control (Figure. 7), and their energy savings, as well as the cost, was used as a basis for its implementation at ORTIA and CTIA.

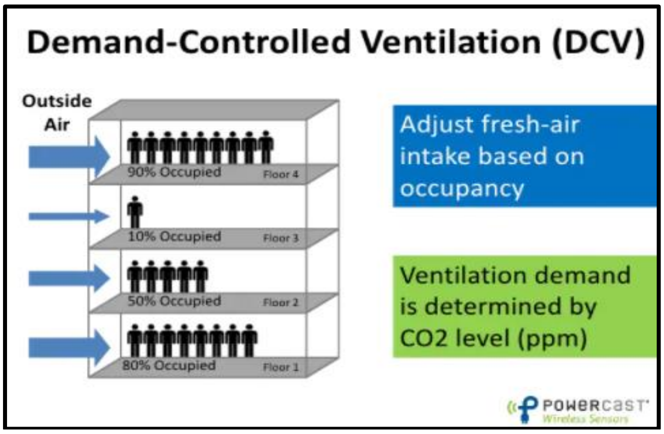


**Figure 7: Fresh Air Demand Control [9].**

The energy savings from KSIA's implementation of the fresh air demand control and active chilled water setpoint control projects are taken from [10] to estimate the energy savings and cost for ORTIA and CTIA which are given in Table 10.For the purposes of the feasibility study, a 20-year lifespan is assumed. The feasibility results are given in Table 11.

**Table 10: Estimated Cost and Energy Savings of the Active Chilled Water set Point Control and Fresh Air Demand Control Interventions for ORTIA and CTIA**

| | Airport | Active Chilled Water Set Point Control | | Fresh Air Demand Control | | Total | |
|---|---|---|---|---|---|---|---|
| | | Energy Savings (kWh) | Capital Cost 2018 Basis (ZAR) | Energy Savings (kWh) | Capital Cost 2018 Basis (ZAR) | Energy Savings (kWh) | Capital Cost 2018 Basis (ZAR) |
| 1 | ORTIA | 30 000 | 134 400.00 | 2 199 828 | 3 217 824.00 | 2 229 828 | 3 352 224.00 |
| 2 | CTIA | 20 000 | 89 600.00 | 1 466 552 | 2 145 216.00 | 1 486 552 | 2 234 816.00 |

**Table 11: Feasibility of Implementing Active Chilled Water Set Point Control and Fresh Air Demand Control for Selected Airports in South Africa**

| | Airport | Year of Implementation | Cost at year of Implementation (ZAR Million) | NPV (ZAR Million) | IRR (%) | Annual kWh Reduction | Annual Cost Savings of kWhs saved (ZAR Million) 2018 basis | Result |
|---|---|---|---|---|---|---|---|---|
| 1 | ORTIA | 2020 | 3.35 | 31.39 | 92.20 | 2 229828.00 | 3.28 | Feasible |
| 2 | CTIA | 2022 | 2.23 | 20.93 | 92.20 | 1 486 552.00 | 2.19 | Feasible |

Table 11 shows that implementing an active chilled water setpoint control and fresh air demand controlis feasible for ORTIA and CTIA.

### 4.3 Implementation Notes for Airports

The projects given here were a guide for airports to begin performing onsite verifications, detailing project specification, checking for feasibility and submissions to management for budget approval.Impact and feasibility indicators will be adjusted as the results of the energy consumption of the sites, their electricity tariffs and light fitting count is analysed. Should there be a shortfall in the expected electricity reduction figures, the carbon footprint reduction can be achieved elsewhere through the renewable energy and alternate energy plants planned for the site.

## CONCLUSIONS

This paper presented the interventions to reduce electricity consumption and their feasibility for nine airports in South Africa. LED lighting retrofits are feasible for ORTIA, CTIA, KSIA, PEIA, BFIA, KIM airports,butare not feasible for EL, GG and KIM. Implementing lighting control technologies are feasible for ORTIA, CTIA, KSIA, PEIA, EL, BFIA, GG, UPIA, KIM. Geyser sleeve technology retrofits in geysers is feasible for ORTIA, CTIA, KSIA, PEIA, EL, BFIA, GG, UPIA, KIM. Replacing terminal building glass facades with double glazing or low emissivity glass is feasible for BFIA and UPIA but is not feasible for ORTIA, CTIA, KSIA, PEIA, EL, GG and KIM. Executing air conditioning interventions to reduce electricity consumption from the grid is feasible for the following airports as follows:

- Solar thermal powered absorption chillers – BFIA and PEIA; and
- Active chilled water setpoint control and fresh air demand control – ORTIA and CTIA.

Ensuring that the interventions presented here are confirmed for each of the airports (including their feasibility) is crucial to reduce electricity consumption in line with the overall plans for renewable and alternative energy for the airports, thereby reducing carbon emissions and ensuring that investment to reduce carbon emissions is efficient.

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